# Space Weather Technical Forecast

Issued on Wednesday, 15 December 2021 at 01:27 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Slight chance of G1/Minor Geomagnetic Storms day 1 (15th). Potentially increasing solar activity.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar Activity was Low, but with increasing frequency of C-class flares though the day, coincident with the development of sunspot regions AR2906 (Cso/Beta) and more especially AR2907 (Dai/Beta-gamma-delta) in the southeastern quadrant. Two other regions are present (also in the southeast quadrant) with AR2905 (Hrx/Alpha) largely dormant and a new unnumbered region close to the southeast limb (Cao/Beta). Another larger sunspot region is on the immediate southeastern limb, but is too foreshortened in available imagery at present to classify the region. This cluster of sunspots will need close attention over the next few days as further developments may increase the chances of significant flaring. A filament eruption from around N45W05 was observed at 14/1200 UTC and a slow CME is evident in STEREO A imagery. This may be earth-directed, however, as yet no evidence is available of this feature in LASCO imagery. Otherwise no Earth-directed CMEs have been observed.

**Solar Wind / Geomagnetic Activity:** The solar wind speed, as measured at L1, was at background levels throughout the period and between 310-330 km/s for much of the day. A slow increase in recent hours to speeds of around 340-350 km/s may be indicative of the onset of a connection to the fast wind from a coronal hole (mostly likely coronal hole 32). Density was mainly above average at 10-15 ppcc, but with a recent rising trend to around 20 ppcc and a peak of nearly 23 ppcc at 14/2346 UTC. The Interplanetary Magnetic Field strength (IMF) Bt was weak between 1 and 8nT. The Bz component was mainly negative, but weak, with a brief maximum dip of -6nT was measured by DSCOVR at 14/0050 UTC. Bz has fluctuated between positive and negative since around 14/1830 UTC. The Phi angle was mostly positive (away from the sun) but has become mainly negative (towards the sun) since 14/1830 UTC. Geomagnetic activity was Quiet (Kp 0-2).

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels with the associated 24-hour integrated fluence below the Active threshold. Fluence of 1.52e6 was observed at 15/0000 UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar Activity is expected to be mainly Low, but with a chance of M-class flares and slight chance of X-class flares given the recently developing and increasing numbers of sunspot regions on the visible disc. Further sunspot regions may rotate onto the visible disc in the coming days to supplement the current risk of significant flares.

**Solar Wind / Geomagnetic Activity:** Solar winds will increase on day 1 (15th) from background to likely become elevated due to the onset of the fast wind from coronal hole 32. Winds should gradually ease later day 2 (16th) and eventually back to slightly elevated or background by the end of day 4 (18th). No further coronal hole enhancements are anticipated during the period. A filament eruption from the northern hemisphere centre disc around 14/1200 UTC is awaiting

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analysis to determine if the subsequent slow CME is earth-directed. Geomagnetic activity is expected to be Unsettled or Active initially on day 1, with a slight chance (20%) of a G1/Minor Storm. Geomagnetic activity will wane again after the peak period of fast wind into days 2 and 3 (16th and 17th) with Quiet conditions predominant.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, although with a slight increasing risk of enhancement with time due to developing sunspot activity. The high energy electron flux (greater than 2 MeV) is expected to be Background to Moderate levels initially. The arrival of the fast wind from a coronal hole on day 1 (15th), has the potential to increase the flux by day 2 or 3 (16th or 17th) with persistently High flux possible by late day 2 or day 3 and perhaps also day 4 (17th), although confidence remains Low for this. The associated 24 hour fluence is expected to persist well below the Active level on day 1, with a slight, but increasing chance of rising above by the end of day 3 and continuing into day 4.

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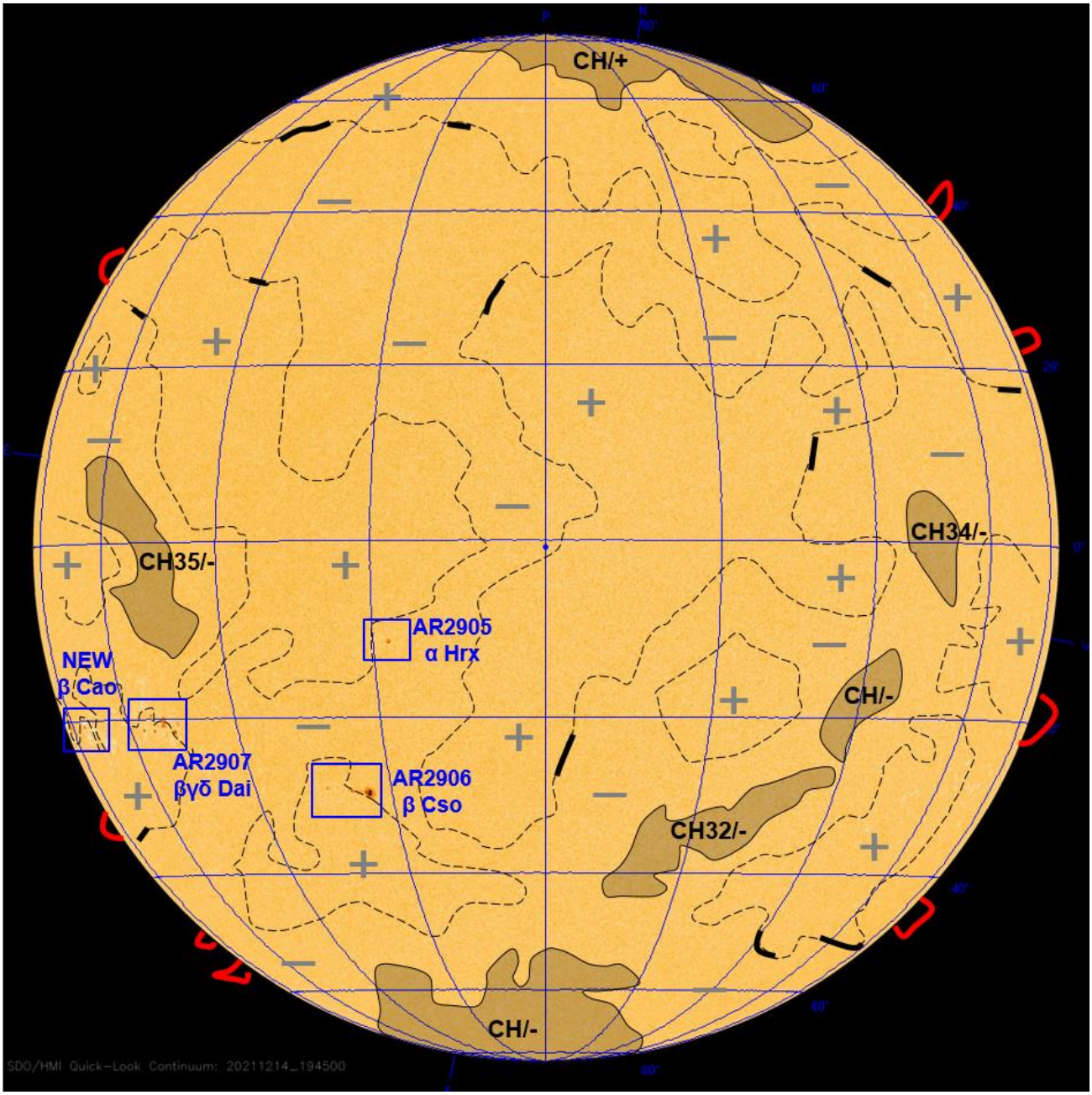
**Figure 1. Solar Analysis Valid 14/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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# Met Office Space Weather Technical Forecast

## Geomagnetic Storms:

A filament eruption from around N45W05 was observed at 14/1200 UTC and a slow CME is evident in STEREO A imagery. This may be earth-directed, however, as yet no evidence is available of this feature in LASCO imagery. Otherwise no Earth-directed CMEs have been observed.

The onset of the connection to coronal hole 32 appears to be occurring at present based on rising solar wind density parameters and magnetic field intensity. Although the solar wind will be initially at background levels, a transition into the fast wind of coronal hole 32 will take place during day 1 (15th) with elevated winds of around 500 km/s likely before gradually easing later day 2 (16th) and eventually back to slightly elevated or background by the end of day 4 (18th). This is supported by Enlil, which has an enhancement occurring early on day 1. No further coronal hole enhancements are anticipated during the period.

Geomagnetic activity is expected to be Unsettled or Active initially on day 1, with a slight chance (20%) of a G1/Minor Storm. Geomagnetic activity will wane again after the peak period of fast wind into days 2 and 3 (16th and 17th) with Quiet conditions predominant.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 20 | 5 | 1 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections - Nil

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## Radio Blackouts - X-Ray Flares:

There are currently four, but likely soon to be five sunspot regions on the visible disc. All are in the southeastern quadrant of the visible disc. AR2907, at present is the most significant region, having developed quickly on the 14th in an area of pre-existing plage field. This means it is more likely to become unstable and flare as pre-existing energy is released. A number of small, but fairly strong spots have emerged in this region, including a delta spot in the centre of the group, highlighting a potential for significant flaring in addition to the numerous C-class flare events observed in the past 12 hours. This region was classified as a Dso/Beta-gamma-delta group, but may soon be reclassified as Dsc/Beta-gamma-delta.

AR2906 (Cso/Beta) also underwent growth and development on the 14th with several C-class flares recorded from this region. Recent development has slowed, but remains a region of interest for notable flares.

AR2905 remains a small and simple sunspot group in the eastern hemisphere close to the equator. A trailer spot briefly attempted to emerge late in the UTC day on the 14th, but is an Hrx/Alpha group for now.

A new, as yet unnumbered region is evident close to the southeast limb. It appears to be a bipolar group and developing rather quickly with an asymmetric penumbra on the trailer portion of the group. This is classified as Cao/Beta, though is still rather foreshortened in available imagery.

There is a further group to the east of the new region. This appears to be larger than the preceding new region, but is too close to the limb to make an accurate assessment at this time.

This cluster of sunspot regions will be closely monitored over the coming days. For now mainly Low activity is expected with a 25% chance of M-class and 5% risk of X-class flares given the current configuration of sunspots on the visible disc. Further active regions are likely to rotate into view over the next week as suggested from the side-view of the Sun provided by STEREO A.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 25 | 25 | 25 | 25 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 5 | 5 |

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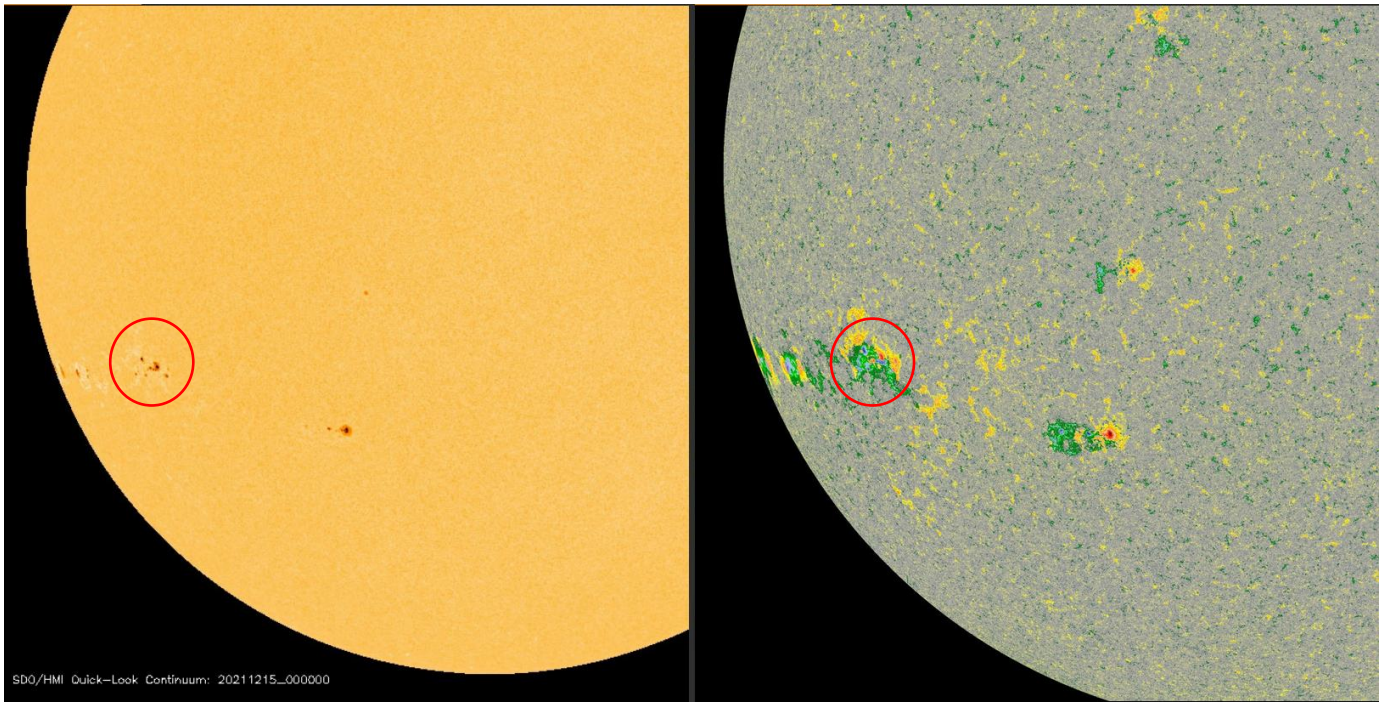
**Figure 2: HMIIMG-IC-FLAT and HMI-MAGNETOGRAM-COLOR imagery valid 15/0000 UTC. AR2907 circled (red).**




## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels. Increasing sunspot activity may warrant a slight increase of chance of S1 over the next few days, but as the regions are in the east quadrant of the solar disc, any large flares are less likely to affect the Earth. They will become more of a risk when they move into the western quadrant if they are still active.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 3 | 3 | 3 | 5 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

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## High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be at Background to Moderate levels initially. The arrival of the fast wind of coronal hole 32 on day 1 (15th), has the potential to increase the flux by day 2 or 3 (16th or 17th) with persistently High flux possible by late day 2 or day 3 and perhaps also day 4 (17th), although confidence remains Low for this.

The associated 24 hour fluence is expected to persist well below the Active level on day 1, with a slight, but increasing chance of rising above by the end of day 3 and continuing into day 4. This is supported by REFM which maintains fluence below the Active threshold.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 5 | 20 | 20 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 3: Latest MOSWOC REFM output.**

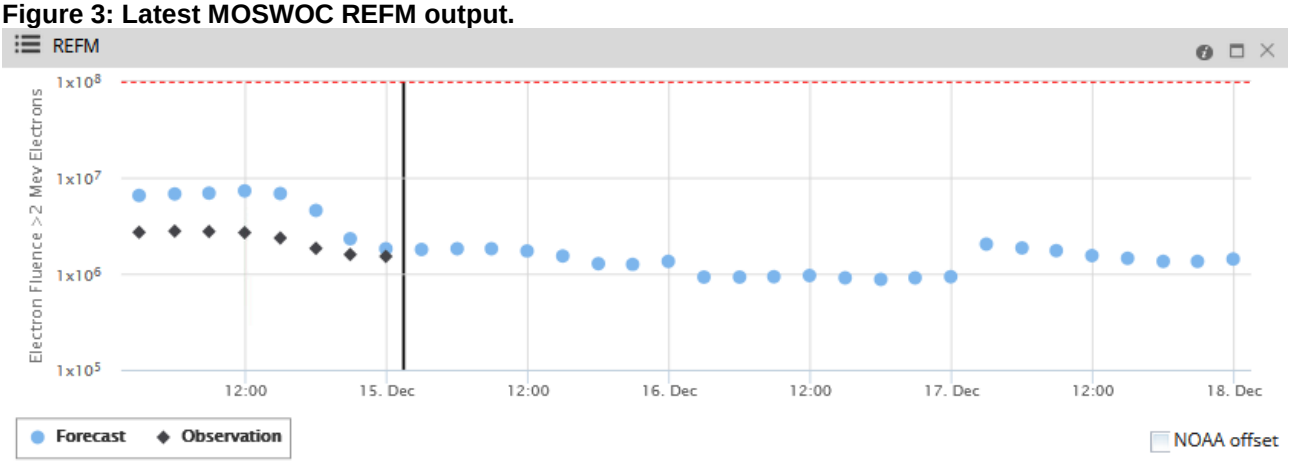


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**Figure 3:**

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